(12) UK Patent Application (19) GB (11) 2 125 253 A

(21) Application No 8221648
(22) Date of filing 27 Jul 1982
(43) Application published 29 Feb 1984
(51) INT CL³ H04M 9/02 H04J 6/00
(52) Domestic classification H4K YF H4M A H4P PX
(56) Documents cited GB 1285223
(58) Field of search H4K H4P H4M

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(54) Data communications system

(57) In a digital communication system for use in a local area network, messages are conveyed over a cable, which may be an electrical cable or an optical fibre cable, using code division multiple access spread spectrum techniques. In such a system the message is modulated on to a quasi-random bit stream whose characteristics form an address for the terminal to which the message is directed.

Such a system is known in specialised radio systems, but is not normally considered suitable for line communication because of inefficient use of the bandwidth. However, in a short-range local area network this disadvantage largely disappears.

inf. lägga på
Subcarrier
ej bara fasskift-
modulation

GB 2 125 253 A

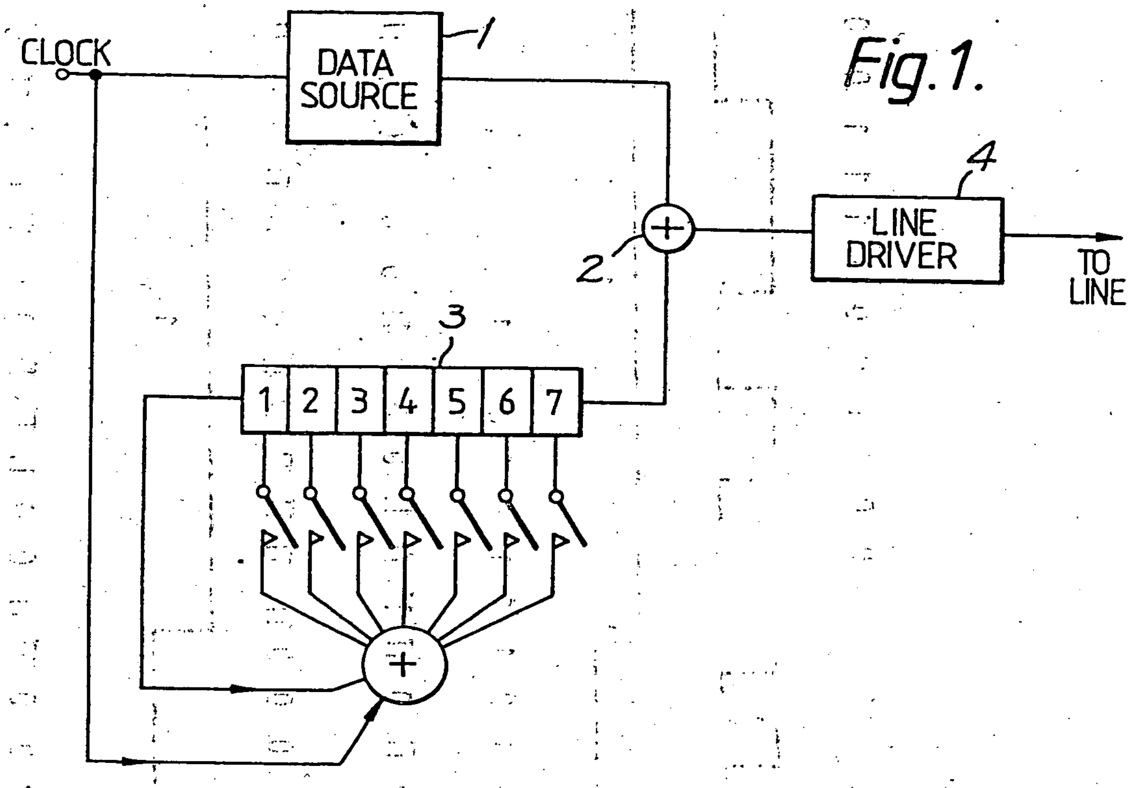

CLOCK
DATA SOURCE
1
2
LINE DRIVER
4
TO LINE
3
1 2 3 4 5 6 7

Fig. 1.

Fig. 2.

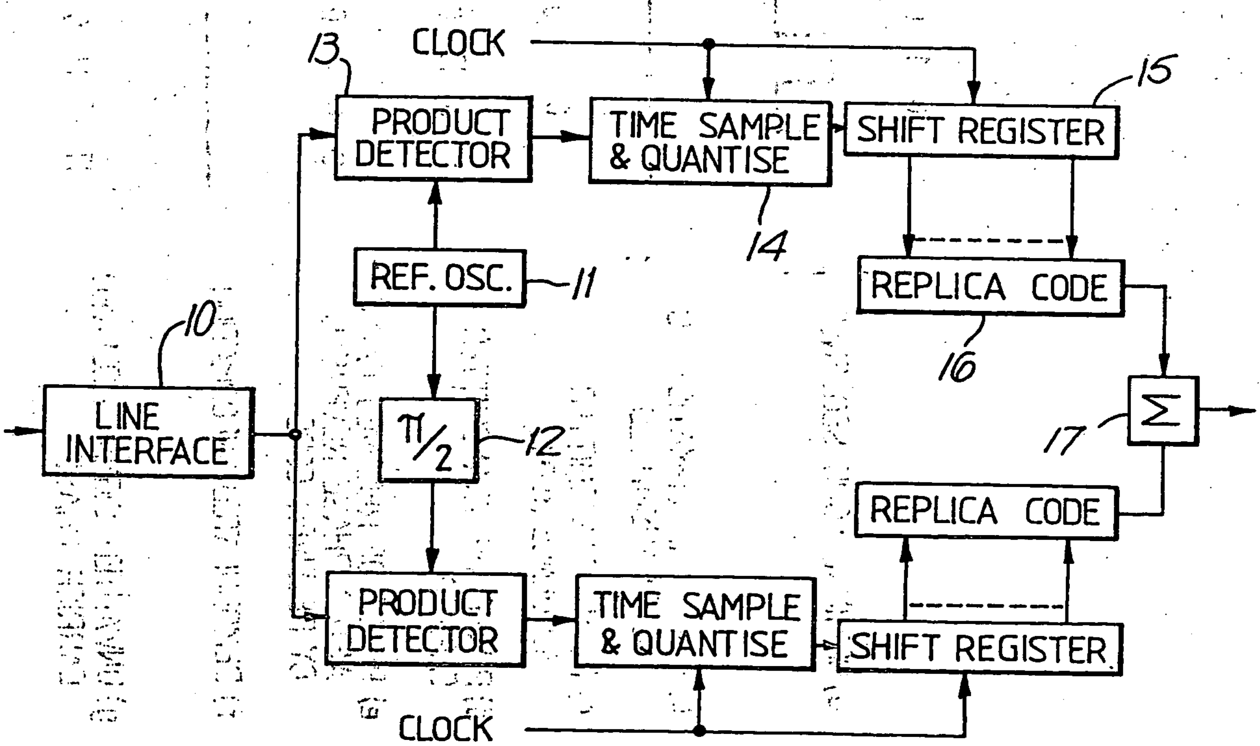
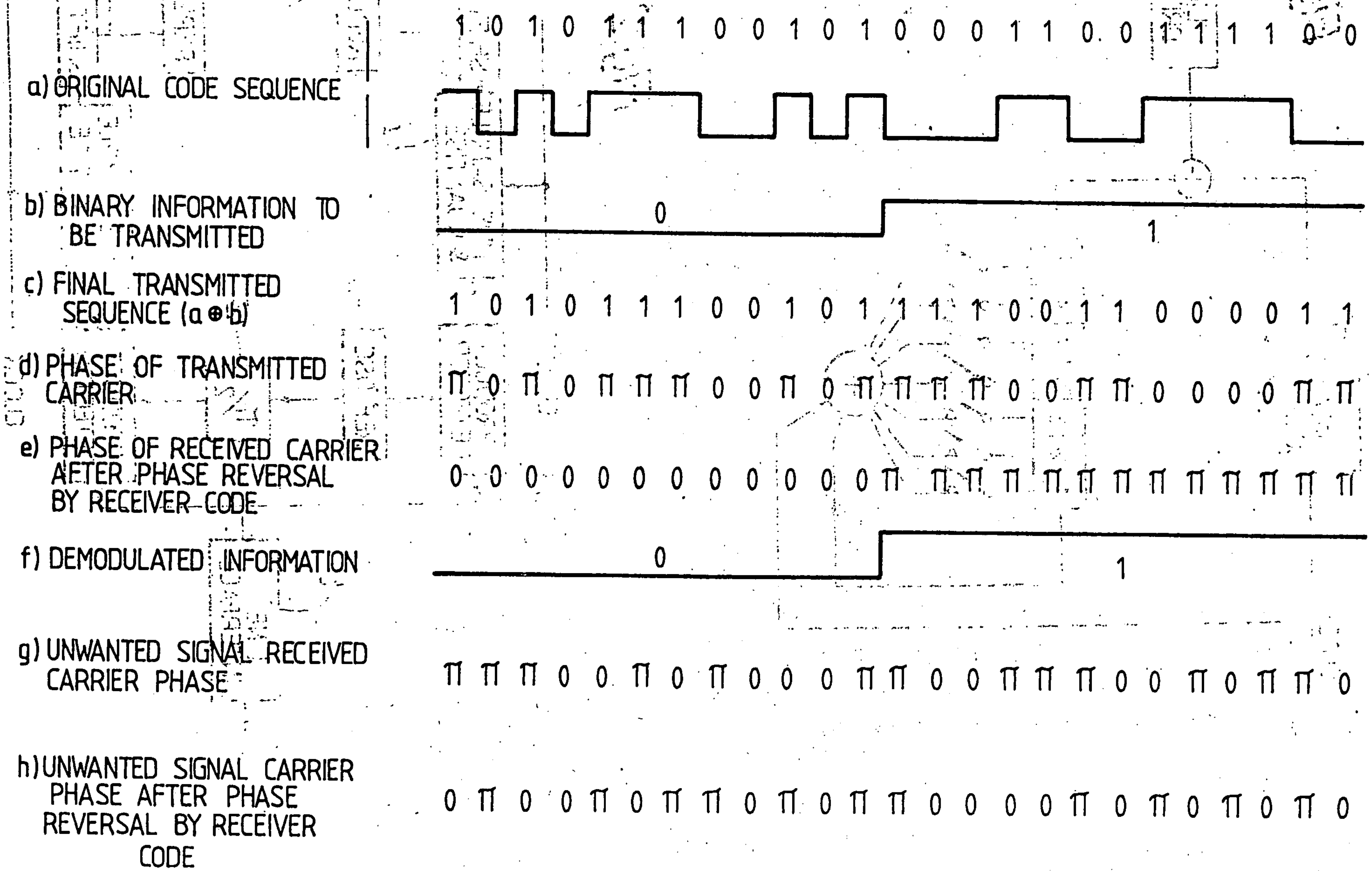

CLOCK
13
PRODUCT DETECTOR
TIME SAMPLE & QUANTISE
SHIFT REGISTER
15
14
REF. OSC.
11
REPLICA CODE
16
10
LINE INTERFACE
π/2
12
Σ
17
REPLICA CODE
PRODUCT DETECTOR
TIME SAMPLE & QUANTISE
SHIFT REGISTER
CLOCK

Fig.3.


1 0 1 0 1 1 1 0 0 1 0 1 0 0 0 1 1 0 0 1 1 1 1 0 0
a) ORIGINAL CODE SEQUENCE
b) BINARY INFORMATION TO BE TRANSMITTED
0
1
c) FINAL TRANSMITTED SEQUENCE (a ⊕ b)
1 0 1 0 1 1 1 0 0 1 0 1 1 1 1 0 0 1 1 0 0 0 0 1 1
d) PHASE OF TRANSMITTED CARRIER
π 0 π 0 π π π 0 0 π 0 π π π π 0 0 π π 0 0 0 0 π π
e) PHASE OF RECEIVED CARRIER AFTER PHASE REVERSAL BY RECEIVER CODE
0 0 0 0 0 0 0 0 0 0 0 0 π π π π π π π π π π π π π
f) DEMODULATED INFORMATION
0
1
g) UNWANTED SIGNAL RECEIVED CARRIER PHASE
π π π 0 0 π 0 π 0 0 0 π π 0 0 π π π 0 0 π 0 π π 0
h) UNWANTED SIGNAL CARRIER PHASE AFTER PHASE REVERSAL BY RECEIVER CODE
0 π 0 0 π 0 π π 0 π 0 π π 0 0 0 0 π 0 π 0 π 0 π 0

SPECIFICATION

Data communications system

The present invention relates to communication systems of the so-called local area network (LAN) type, i.e. to such systems where the system terminals are fairly closely spaced.

Typical systems of the above type are used in an office block or on a factory site where a number of terminals have to be provided in a fairly concentrated area. One example of such a system is the by-pass system described in our Application No. 8113348 (S. F. Smith—R. V. Latin 3-1), which describes an add-on network which may be of the open or closed-loop type for an existing telephone exchange such as a PABX. An object of the invention is to provide a system such as, for instance that of the above application, with an improved and economical way of conveying the information.

According to the invention there is provided a digital communication distribution system, which includes a number of terminals each of which can originate and/or receive messages, and a physical transmission path linking said terminals, wherein the messages to be conveyed are sent using spread spectrum techniques with each message to be sent modulated in a manner appropriate to the station or stations for which that message is intended, and wherein at each terminal at which messages can be received all incoming messages are offered for correlation to the address or addresses appropriate to that station, the correlation means for a said terminal only responding to messages intended for that terminal.

The particular form of spread spectrum techniques used herein is code division multiple access (CDMA), and use of CDMA in a spread spectrum system is known in certain other fields, such as in specialised military and satellite radio systems. However, its use in non radio, i.e. cable (either electrical or optical) systems is unusual. Hitherto it has usually been considered that the wide bandwidth, and comparatively inefficient bandwidth utilisation would make such systems unsuitable for use in cable systems. However, we have appreciated that CDMA spread spectrum systems are in fact so usable, especially where the system is relatively localised.

In such a system, in which the modulation technique used is sometimes called pseudo-noise modulation, at the transmitter a modulated RF carrier is subjected to irregular phase reversals in a modulator. These reversals are controlled by the output of a code generator, which in turn is controlled by a stable oscillator or clock of frequency f_c. The code generator produces a stream of binary digits in a pseudo-random sequence, and the modulation data, which is 1 or 0 bits, is superimposed on the pseudo-random sequence. The resulting waveform, which is in effect a combination of the pseudo-random sequence and the modulation data, is applied to the balance modulator, which leaves the RF carrier unchanged for a 0 bit in the resulting waveform and produces a phase reversal for a 1 bit.

The pseudo-random sequence is derived, for example from a feed-back shift register. With *n* stages there is a sequence of (2^n-1) digits before the sequence repeats. By varying the settings of the feedback switches, various different sequences can be generated. In the system to be described below, 7 stages are used, which gives a sequence of (2^7-1) bits, although in some cases such a shift register may have as many as 15 stages, to give a sequence of $(2^{15}-1)$.

At a receiver in such a system, the incoming RF signal is passed through an identical balanced modulator driven from an identical code generator. If the same code is generated, and if the two codes are in synchronism, the effect of the phase reversals is nullified. To achieve rapid synchronism, the clock driving the receiver code is run at a slightly different frequency from that of the transmitter oscillator, so that the two codes drift across each other. A correlator gives an output only when the two codes are in synchronism, which output can be used to hold the receiver clock at the correct frequency and phase. If the transmitter and receiver codes differ there is no output from the correlator.

The clock frequency—and also the frequency of the pseudo-random code sequence—is much greater than the frequency of the modulation data. Thus the pseudo-random phase reversals cause the spectrum of the original modulated wave to be spread. The envelope of the spread spectrum is a sin x/x function, and the energy is spread over a bandwidth of approximately $2f_c$. Unwanted signals, if not already spread, are spread by the action of the receiver phase reversals, and appear in the receiver output as noise. Spread signals using a different code also appear as noise.

Thus such a system uses a number of signals all of which occupy the same frequency band at the same time, and this gives a number of features which are useful in a LAN system. These features may be summarized as follows:—

(a) Any user can access the system at any time without having to wait for a free channel. Thus there are no call collisions or blocked calls in the usual sense, although traffic is eventually limited by the availability of plant and associated software.

(b) There is no hard limit to the number of active users that can be handled simultaneously by the system. When the number of active users exceeds the design value, the result is a degradation of performance for all users rather than any user being denied access. Thus the system exhibits graceful degradation.

(c) Since each potential user is assigned a unique signal set, or "code", a resultant "fringe benefit" is message privacy. This is, of course, privacy with respect to the casual listener, which is not to be confused with encryption; thus

message interception by a suitably equipped third party is not precluded.

(d) As each user retains his own code, there is no channel switching or address changes as he changes his location.

(e) Since all users use the same band, the user hardware, i.e. the line terminations, can be identical.

The physical transmission path is either an electrical cable such as a coaxial cable, or an optical fibre cable.

Equipment embodying the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 shows part of a transmitter for use in a system embodying the invention.

Figure 2 shows in block diagram form part of a receiver for a system embodying the invention.

Figure 3 shows the effect of the receiver correlator on wanted and unwanted spread signals, the code rate and the information rate not being to scale.

We now refer to Figure 1, which shows the essentials of the transmit part of a line interface in a system embodying the invention. In the present arrangement the available bandwidth is 100 KHz, in which case the total aggregate device information rate is 240 kb/s. Thus the system can handle 16 devices each of which operates at 2.4 kb/s, or a variety of different speed devices whose bit rates aggregate at 240 kb/s. As already indicated, if this presented bit rate is exceeded, graceful degradation of the performances of all devices occur. Note that if the system uses a wider bandwidth, e.g. by the use of coaxial cables, or optical fibre cables, the total aggregate information rate can easily be increased, e.g. to above 2400 kb/s in a coaxial cable system.

In Figure 1, the clock pulse source controls the data source 1 the output of which feeds a modulation device 2. There is also a feedback shift register 3, whose switches are set to generate a desired sequence. This sequence, which repeats, is the code for a message to be sent, and the switches are set to the code for a message's destination when the message is to be sent. The CDMA code thus generated is applied to the modulation device 2, whose output is applied via a line driver 4 to the line.

Using a seven-stage shift register with variable taps, as shown, which taps can be set according to an address-code look-up table, 18 m-sequence, i.e. 18 unique maximum length address codes can be defined, 16 for devices or terminals of the system 1 for broadcast, and 1 for gaining access to another LAN via a "gateway" device. The code length for each information bit is 127 code bits, which gives 21db margin against interference by other devices. This is usually called the jamming margin.

Although the variable taps are shown as being mechanical switches, they are normally electronic gating devices controlled from the look-up table, which is itself controlled for instance from a device keyboard.

Figure 2 shows the essential features of a receiver for use with transmitters of the type shown in Figure 1. This is based on the matched filter summation detection technique, and is responsive to two "replied codes", one unique to the device including the circuitry of Figure 2 and one for receiving broadcast transmission.

The line interface 10 applies the received signals from the line, amplified if necessary, to two detection channels, one for the "device unique" code and one for the broadcast code. Both channels are supplied by a reference oscillator 11, one direct and one via a $\pi/2$ phase shifter 12.

As the two channels are similar, only the upper one will be described. Here we have a product detector 13 fed from the reference oscillator 11 and interface 10, which produces an output in synchronism with the original message. This is sampled and quartered under clock pulse control in the block 14 from which it is applied to a shift register 15. Here the bit stream is correlated with the appropriate replica code from a store 16 and the output applied via the summator 17 to the utilisation means.

Figure 3 illustrates the process used both for transmission and reception, including the effect of the receiver correlation on wanted and unwanted spread signals. The code rate and information rate are not to scale, but the figure does show that the code rate is a multiple of the information rate.

Claims

1. A digital communication distribution system, which includes a number of terminals each of which can originate and/or receive messages, and a physical transmission path linking said terminals, wherein the messages to be conveyed are sent using spread spectrum techniques with each message to be sent modulated in a manner appropriate to the station or stations for which that message is intended, and wherein at each terminal at which messages can be received all incoming messages are offered for correlation to the address or addresses appropriate to that station, the correlation means for a said terminal only responding to messages intended for that terminal.

2. A digital communication distribution system, which includes a number of terminals each of which can originate and/or receive voice and/or non-voice messages, and a physical transmission medium linking said terminals, wherein the messages to be conveyed are sent using code division multiple access spread spectrum techniques with each message to be sent modulated on to a digital code appropriate to the station or stations for which that message is intended, and wherein at each terminal at which messages can be received all incoming messages are offered for correlation to the address code or codes appropriate to that station, the correlation means for a said terminal only responding to messages intended for that terminal.

3. A system as claimed in claim 2, in which a

terminal at which messages can be originated includes a feedback shift register with variable control taps, and control means for setting said taps to cause the shift register to repeatedly generate a code sequence appropriate to the terminal or terminals for which the message is intended.

4. A system as claimed in claim 1, 2 or 3, and in which the physical transmission path is a coaxial electrical cable.

5. A system as claimed in claim 1, 2 or 3, and in which the physical transmission path is an optical fibre cable.

6. A data communication system, substantially as described with reference to the accompanying drawings.

New claims or amendments to claims filed on 25 May 1983

New or amended claims:—

7. A digital communication distribution system, which includes a number of terminals each of which can originate and/or receive messages, and a physical transmission path such as an electrical cable or an optical fibre cable linking said terminals, wherein at a transmitting terminal a modulated RF carrier is subjected to irregular phase reversals in a balanced modulator, wherein the phase reversals are controlled by the output of a code generator which is itself controlled by a stable oscillator or clock, wherein the code generator produces a stream of binary digits in a pseudo-random sequence, the modulation data which consists of 1 or 0 bits being superimposed on the binary digits of pseudo-random sequence, wherein the waveform thus produced, which is a combination of the pseudo-random sequence and the modulation data, is applied to the balanced modulator in such a way as to leave the RF carrier unchanged for a 0 condition in said combination and to produce a phase reversal of the RF carrier for a 1 condition, wherein at a receiving terminal the incoming RF signal is passed through a balanced modulator identical to that used for transmission, which balanced modulator is controlled by a code generator identical to that used for transmission and which generates a code, or one of a plurality of codes, appropriate to its terminal, wherein if the code generated by the receiving terminal code generator is the same as that used to produce the incoming signal, and if the two codes are in synchronism the effect of the phase reversals is nullified, wherein a correlator gives an output when the two codes are in synchronism which maintains them in synchronism, and wherein the signal with its phase reversals nullified is the same as the data used at the transmitting end to produce the signal being detected.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1984. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.